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System and Method for Well Workover with Horizontal Tree

Field of the Invention

The present invention relates to the techniques for workover of wells and, more particularly, to a system and method for workover of a well with a horizontal tree.

Background of the Invention

While wells have been conventionally completed with trees wherein the production fluid passes vertically from the well through the tree, some more recent wells have been completed with a horizontal tree, wherein the production fluid passes laterally through a side port in the tree. Because the production fluid from the well passes laterally, plugs may be installed in the bores of both a tubing hanger and a tree cap above the side port in the horizontal tree to provide redundant seals.

Workover operations on a horizontal tree are conventionally performed from a floating drilling rig which connects a subsea drilling BOP to the top of the horizontal tree, with the drilling riser extending from the surface to the top of the BOP. When a big bore riser and BOP stack are placed on top of the horizontal tree, various types of workover operations may be performed, including pulling and reinstalling a tubing string. However, due to the high expense and time of installing the subsea drilling BOP and large diameter riser, especially in deeper water, it is desirable to avoid that procedure when it is possible to do so. It is

frequently necessary to perform a workover operation which does not require pulling the tubing, thereby potentially avoiding the significant expense of installing/removing the subsea drilling BOP and large diameter riser.

U.S. Patent 6,367,551 provides a method of workover in a well with a horizontal tree. The techniques disclosed in this patent have several shortcomings which have limited acceptance. First, the shuttle valve in the tree cap may be prone to sticking open when the riser is removed. Second, there is no technique to test the closure of the shuttle valve while the riser is in place because the riser connection must actually be removed before the valve closes, thereby raising a potential significant problem if the valve does stick and/or does not close completely, or develops leaks, after the riser connection is removed. Third, the flow path from the annulus line on the riser to the well annulus goes into the horizontal tree, through the aforementioned shuttle valve, and then bypasses the tubing hanger by going radially outwardly and then radially inwardly through the tree housing making for a complex annulus flow path that may be prone to problems. Further, the tree cap must seal to both the tubing hanger and the test tree. With this tree cap/tubing hanger arrangement, the entire tubing hanger may need to be removed if problems occur with the tree cap, or with seals between the tree cap and the tubing hanger, and/or the complicated annulus flow path through the tree cap.

When it is not necessary to pull the tubing, then all that may be required for the workover operation is a small diameter riser, which may be referred to as a slimline OD riser, connected to the top of the tree, with a small diameter BOP

on the surface, and to establish a communication path to both the tubing bore and the tubing annulus below the tubing hanger. The bore in the slimline riser needs to have a sufficient ID to pull and reinstall the plugs in the tree cap and tubing hanger, and to provide full bore access to the tubing in the well but does not require an ID large enough to pull the tubing hanger. Workover operations using a slimline OD riser are relatively economical, particularly in deep water applications, because the subsea BOP stack and large OD riser are not required. Using a slimline riser thus provides considerable economy to the workover operation, such that these operations are commonly known as "quickie" workovers.

Given the time and cost of installing a drilling BOP and large diameter riser, especially at substantial well depths, the inventor has determined that it would be highly desirable to provide a system which is much more likely to require only the less expensive workover. Those of skill in the art will appreciate the present invention which provides solutions to the aforementioned problems and other related problems.

Summary of the Invention

It is an object of the present invention to provide an improved horizontal tree workover system for use when a subsea drilling BOP is not required to be utilized.

It is yet another object of the present invention to provide an improved well production system.

These and other objects, features, and advantages of the present invention will become apparent from the drawings, the descriptions given herein, and the appended claims. However, it will be understood that any listed objects and advantages of the invention are intended only as an aid in understanding certain aspects of the invention, are not intended to limit the invention in any way, and do not form a comprehensive or exclusive list of objects, features, and advantages.

In a preferred embodiment of the present invention, a workover system for a subsea horizontal tree is provided which does not utilize a subsea drilling BOP. The subsea horizontal tree comprises a tubing hanger supporting a production tubing string in a well such as an oil and/or gas well. The well comprises a casing string wherein an annulus or volume is provided between the casing string and the tubing string. In one possible embodiment, the workover system may comprise one or more elements such as, for instance, a riser extending from the subsea horizontal tree towards the surface and an adapter for connecting the riser with the subsea horizontal tree. An annulus line for

communication with the annulus extends upwardly towards the surface with the riser and may be utilized to establish circulation through the production tubing and the annulus. A lower end of the annulus line may be connected to a port such as a side port for communication with the annulus. One or more valves are preferably mounted between the lower end of the annulus line and the annulus for controlling fluid flow between the annulus line and the annulus. In one embodiment, a control valve may be mounted, for instance, externally to the subsea horizontal tree. In another embodiment, a valve may be provided for annulus control at a position within the tubing hanger. In another embodiment, a receptacle may be mounted to the horizontal tree for receiving and guiding a lower end of the annulus line into fluid communication with the side port. One or more annulus control valves may, for example, be mounted adjacent to the receptacle external to the horizontal tree.

The system may further comprise a tree cap, and/or an insertable isolation sleeve insertable through the tree cap. The isolation sleeve preferably seals with the tubing hanger. In one embodiment, the side port is spaced axially above the tree cap and communicates with the annulus along a flow path adjacent to the insertable isolation sleeve through the tree cap. In another embodiment, the side port is defined within the adapter. In another embodiment, the side port is defined between the tree cap and the tubing hanger. Yet in another embodiment, the side port is defined below the tubing hanger. In a presently preferred embodiment, the tree cap and the tubing hanger are formed as separate components axially spaced apart with respect to each other. In one

embodiment, the tubing hanger defines a tubing hanger central bore therethrough in communication with the tubing. The tubing hanger may further define a vertical flow path positioned radially offset from the tubing hanger central bore. A control valve may also be positioned along the vertical flow passageway for controlling fluid flow between the annulus line and the annulus.

Brief Description of the Drawings

Figure 1 discloses one version of a horizontal tree adapted for a workover operation using a slimline OD riser.

Figure 2 is another embodiment of a horizontal tree adapted for a quickie workover.

Figure 3 is a third alternative of a horizontal tree adapted for a quickie workover.

Figure 4 is yet another embodiment of a horizontal tree workover application using a slimline OD riser.

Detailed Description of Preferred Embodiments

The system and method of the present invention includes various embodiments for conducting a quickie workover on a horizontal tree. The workover operations do not involve the installation of a subsea BOP stack, and only a slimline OD riser and an annulus flow line in parallel with the riser are required, along with ancillary surface equipment, to perform the workover operation.

Referring to Figure 1, the workover system 10 includes a wellhead W having a conductor casing string CC extending downward therefrom, and supporting a casing hanger CH from the wellhead, with a casing string CS extending downward from the casing hanger. A production tubing string PTS passes upward through the wellhead W and into the horizontal spool tree 12, which includes a production valve 14 for controlling fluid flow through the side port in the tree which is in communication with the production tubing string PTS. Production valve 14 may be hydraulically and/or manually controllable. A slimline OD riser 16 may be run in the well together with an annulus line umbilical 18 external of the riser 16.

When the riser 16 is latched on top of the tree 12 using an adapter 20, the plugs (not shown in Figure 1 – but see Figure 2) are pulled from both the tree cap 22 and the tubing hanger 24. An isolation sleeve 26 may then be run inside the riser 16 and mechanically locked into a locking profile on the adapter 20, with the isolation sleeve 26, at least in this embodiment, being sealed to both the

adapter 20 and the tubing hanger 24 by one or more seals 28, 30. The bore on the isolation sleeve 26 thus provides full bore access to the production tubing string PTS.

Annulus access is achieved utilizing the annulus line umbilical 18 which passes through a side port 19 in the adapter 20. In this embodiment, adaptor 20 is utilized above tree cap 22. The flow path then extends past tree cap 22 by any suitable means such as a flow path between isolation sleeve 26 and tree cap 22, or other suitable flow path (not shown), through preferred substantially vertical flow path 34, and into the annulus of the tree surrounding the isolation sleeve 26. A ball valve 32 provided in a vertically extending passageway 34 in the tubing hanger 24 thus provides control between the annulus surrounding the production tubing string and the annulus line umbilical 18. Thus, it is possible to establish circulation to circulate fluid through the production tubing string PTS and then through the annulus. Ball valve 32 is preferably hydraulically and/or manually operable, like valve 14. Unlike, the prior art valve system, ball valve 32 can be tested as desired. Latching dogs 36 or a latching ring may be used to axially fix the isolation sleeve 26 to the adapter or other latching means may be utilized. Conventional dogs or locking rings may be used to secure each of the tree cap 22 and the tubing hanger 24 within the horizontal tree 12, with conventional seals between the tree cap and the horizontal tree, and between the tubing hanger 10 and the horizontal tree. In one presently preferred embodiment, significant complexity over the prior art is achieved because no seal is required between the tree cap 22 and either the adapter 20, the tubing

hanger 24, or the isolation sleeve 26.

In Figures 2, 3, and 4, the same numerals are used to depict similar components. In Figure 2, the slimline OD riser 16 is also run in with an annulus line umbilical 18 positioned alongside the riser. The riser again is latched to the top of the tree 12 with connector 52, which is a simplified adapter. In the system 40, the lower end of the annulus line 18 is stabbed into a receptacle 42 positioned on or about the tree spool. One or more valves 43 are positioned on the receptacle, exterior of the receptacle, or between the receptacle and the tree spool 12 to control fluid flow from the umbilical line 18 to the annulus surrounding the production tubing string. Plugs 46, 48 are pulled from the tree cap and the tubing hanger to allow access to the inside of the production tubing string in the well. Annulus access is achieved by providing a connection from the umbilical 18 to the annulus at a position below the tubing hanger thereby bypassing the need to circulate fluid through the preferably vertical flow path in tubing hanger 24. Therefore, one advantage of the system 40 as shown in Fig. 2 is that the annulus valve 32 in the tubing hanger does not have to be operated by opening and/or closing during the quickie workover operation. Figure 2 shows the plugs 46, 48 still in the tree cap and the tubing hanger, respectively. Because flow from the annulus is already isolated by the seals of tubing hanger 24, this embodiment does not require the use of an isolation sleeve as shown. However, if desired, the isolation sleeve or a protection sleeve may be utilized.

In Figure 3, the slimline OD riser 16 is run with the annulus line umbilical 18. alongside. The riser 16 is latched to the top of the tree spool 12 with

connector 52. The lower end of the annulus line 18 is stabbed into receptacle 42 positioned on or about the tree spool. In the system 50, valve 54 thus controls fluid flow between the annulus line 18 and the annulus about the isolation sleeve 26. The plugs are then pulled from the tree cap and the tubing hanger, and the isolation sleeve 26 is run in through the riser and locked into the tree cap by connector 36. The isolation sleeve 26 may be sealed to the tree cap 22 (instead of adaptor 20 as in Figure 1) and to the tubing hanger 24. The bore through the isolation sleeve 26 again provides full bore access from the riser ID to the production tubing string PTS for fluid flow or, if desired, for running a wireline tool or a coiled tubing string into the production tubing string, or other purposes. The annulus access is obtained from a line 18 for connection to the region below the tree cap 22 and above the tubing hanger 24 through port 55 in the tree spool 12. The annulus path continues through the annulus valve 32, through the preferably vertical passageway in the tubing hanger 24 to the annulus between CS and PTS below the tubing hanger 24. Valve 55 is preferably hydraulically or manually controllable.

In Figure 4, the slimline OD riser is run with the annulus line umbilical 18, and the riser 16 may be latched to the top of the tree with adapter 20. The lower end of the annulus line is then stabbed into a receptacle 42 on or about the tree spool below tubing hanger 24 to provide direct access to the annulus between the production tubing string PTS and the casing string CS. The plugs are pulled from the tree cap and the tubing hanger, and an isolation sleeve 26 is run inside the riser and locked into a profile in the adapter 20 by connector 36, with the

isolation sleeve being sealed to both the adapter and the tubing hanger. The bore in the isolation sleeve again provides full access to the production tubing string PTS. Annulus access is achieved from the line 18 to the tubing annulus below the production tubing hanger 24. Suitable controllable valves for annulus line 18 may be provided, such as in the general mounting stabbing structure 42. Note that the isolation sleeve and arrangement shown in Figure 2 might be utilized, if desired, to avoid the need for adaptor 20.

Note that the use of separate wellhead cap 22 and tubing hanger 24 result in redundant seals for more safely sealing off the well. In this embodiment, no additional seals are therefore required between wellhead cap 22 and tubing hanger 24. The resulting structure is simpler and therefore more reliable. As well, if desired, the well head cap 22 could be pulled without requiring pulling out the tubing hanger 24. This arrangement also lends itself to much more flexibility in positioning the annulus port in the well spool, such as above both well head cap 22 and tubing hanger 24, between well head cap 22 and tubing hanger 24, or below tubing hanger 24. Different types of isolation sleeves 26 may be utilized and different connections to the risers, such as connector 20, may be utilized. The valves for controlling annulus flow do not require a special physical connection between the annulus valve and the connection to the riser, such as that shown in the prior art wherein in one embodiment the weight of the connection opens the valve. Thus, the present invention provides a simpler, more reliable, and much more flexible system and methods for well workovers with horizontal tree.

The foregoing disclosure and description of the invention is illustrative and explanatory of preferred embodiments. It would be appreciated by those skilled in the art that various changes in the size, shape of materials, as well in the details of the illustrated construction or combination of features discussed herein may be made without departing from the spirit of the invention, which is defined by the following claims.